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POLLEN MORPHOLOGY IN RELATION TO TAXONOMY AND PLANT GEOGRAPHY OF RESEDACEAE*

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ABSTRACT

Pollen morphological studies on 5 genera and 23 species have been made in the present investigation. Resedaceae is a stenopalynous family. Out of the three tribes, the tribe Cayluseeae is quite distinct pollen morphologically due to larger pollen size, apertural granules and exine ornamentation. The tribe Resedeae and Astrocarpae show close affinity. *Reseda arabica* Boiss. has larger pollen grains and stands apart in the tribe Resedeae. In this character it approaches the *Caylusea* sp. of the tribe Cayluseeae but in other pollen character they differ.

The apertural granules in this family is interesting. Its nature, origin and significance will be useful. These apertural granules in this family suggest its closer relationship with the tribe Cleomae of the family Capparaceae from the palynological point of view.

INTRODUCTION

Mohl (1834) described the pollen grains of *Reseda lutea* and *R. odoratissima*. Muller (1857), in his monographic work on the family Resedaceae, gave a detailed account on the pollen character with figures. Report of the presence of Resedaceae pollen grains in the honey is available from the work of Armbruster and Oenike (1929), Griebel (1930) and de Mandia (1939). Erdtman (1952) described eight species from four genera and Ikuse (1956) reported from Japan the pollen grains of two species. From the survey of available literature it is found that little attempt has been made on pollen morphological study on this small mediterranean family.

In the present investigation 5 genera and 23 species have been worked out palynologically to throw some light on the phylogeny of their family.

Taxonomical position:

Resedaceae is a small family with 6 genera and about 65 species. The genus *Reseda* alone includes about 50 species (Bolle, 1960).

This family is differently treated by different botanists. Jussieu (1789) treated *Reseda* under "Genera Capparidibus affinia"; Brongniart (1850) under Cruciferineae; Bentham and Hooker (1862) under the Cohert Parietales; and Warming (1890) placed it under Cistiflorae. Kerner (1891) and Hutchinson (1969) include it under the order Resedales. Takhtajan (1969) placed Resedaceae under the order Capparales of the super order Dillenianea and sub-class Dilleniidae.

This family, due to small and inconspicuous petals in valvate aestivation, presence of disk and tendency to zygomorphy of flower, has been held as an advanced family.

Geographical distribution:

The family Resedaceae is chiefly confined to the mediterranean region, specially abundant on calcareous soil (Andrews, 1950; Balfour, 1887; Boissier, 1867; Durand & Schinz, 1898; Harvey & Sonder, 1860; Hooker, l.c.; Hutchinson, l.c.; Moris, 1837; Oliver, 1868; Post, 1932; Rendel, 1959 and Thonner, 1918). It extends eastwards through Persia to Northwest India and

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southwards to the mountain of Abyssinia and Somaliland. At Cape it is represented by four endemic species of the genus *Oligomeris*. Whereas the fifth species *Ol. linifolia* has a wide distribution from Canary Islands through north Africa to northern India and also in California and New Mexico. Northwards its limit is upto central Russia, North Germany and Scotland represented there by two native species, *Reseda lutea* and *R. luteola*. In south of Africa only one genuine species is found i.e., *Oligomeris capensis* whereas *Reseda alba* and *R. odorata* have been found under cultivation (Marloth, 1913). The European species *R. lutea* extends eastwards upto Afghanistan.

MATERIAL AND METHOD

This investigation is based on polliniferous material from the herbarium specimens. The material was obtained from the Central National Herbarium (CNH), Calcutta by courtsey of Dr. M. P. Nayar, the Keeper of the Herbarium.

The pollen was acetolysed by Erdtman's (l.c.) method and was studied with an Olympus light microscope with × 15 eyepieces and 1.3 apochromatic oil immersion objective (×100). The photomicrographs were taken at × 1000. 25 measurements were taken for the polar axis and the equatorial diameter for each species. In case of insufficient pollen grains, 10 measurements were taken. Some morphological terms are according to Faegri and Iversen (1964). The slides have been deposited in the sporotheca of the Botanical Survey of India.

The family has been treated according to Bolle (l.c.) in Engler und Prantl "Die Naturlichen Pflanzenfamilie" as follows:

Tribe I	:	Resedeae	Genus :	1. *Oligomeris* 2. *Ochradenus* 3. *Reseda*
Tribe II	:	Cayluseeae	Genus :	4. *Caylusea*
Tribe III	:	Astrocarpeae	Genus :	5. *Astrocaprus*

OBSERVATION

General pollen morphology:

Pollen grains isopolar, equiaxis or longiaxis. Shape prolate to prolate spheroidal in meridional view and semi-angular in polar view.

Three apertures, equatorially situated. Ectoaperture (colpa) extends upto poles, colpal ends tapering, colpal membrane smooth. Endoaperture distinguished by the presence of granules at the colpal region. Granules variously distributed—sometimes confined to the middle region and sometimes occupy the entire or part of the colpal length.

Exine ornamentation finely reticulate, semi-tectate. Ektexine thicker than endexine.

TRIBE I: RESEDEAE (Plate I: Figs. 1-35; Plate II: Figs. 36-59).

Oligomeris drageana (Presl) Muller-Argov. (Africa/CNH 30070/Pr. no. 4544).

Pollen grains 3-colporate. Prolate spheroidal (23.4×21.4 μ). P/E ratio 8/7. Ectoaperture 22×2 μ Colpi membrane smooth. Endoaperture 4×2 μ granulate. Exine 1.5 μ reticulate, lumina 0.5 μ to 1 μ

Ol. linifolia (Vahl) Macb. (syn. *Ol. glaucescens*, Cambess.).

Pollen grains 3-colporate. Prolate (21.6×17.3 μ). P/E ratio 8/6. Ectoaperture 19.5×3 μ Colpi membrane smooth. Endoaperture 3×3 μ granulate. Exine 1.5 μ, reticulate, lumina 0.5 μ to 1 μ

Ochradenus baccatus Delile (Syria/CNH 30087/Pr. no. 6589).

Pollen grains 3-colporate. Subprolate 25.8×21.4 μ). P/E ratio 8/6. Ectoaperture 20×3 μ. Colpi membrane smooth. Endoaperture 3×3 μ granulate. Exine 1.5 μ, reticulate, lumina 0.5 μ to 1.5 μ

Reseda alba L. (India/CNH 29872/Pr. no. 6608).

Pollen grains 3-colporate. Subprolate (24.8×21.7 μ). P/E ratio 8/7. Ectoaperture 21.0×2 μ Endoaperture 14×2 μ, granulate. Exine 1.6 μ, reticulate, lumina 0.5 μ to 1.5 μ hetrobrochate. Lumina

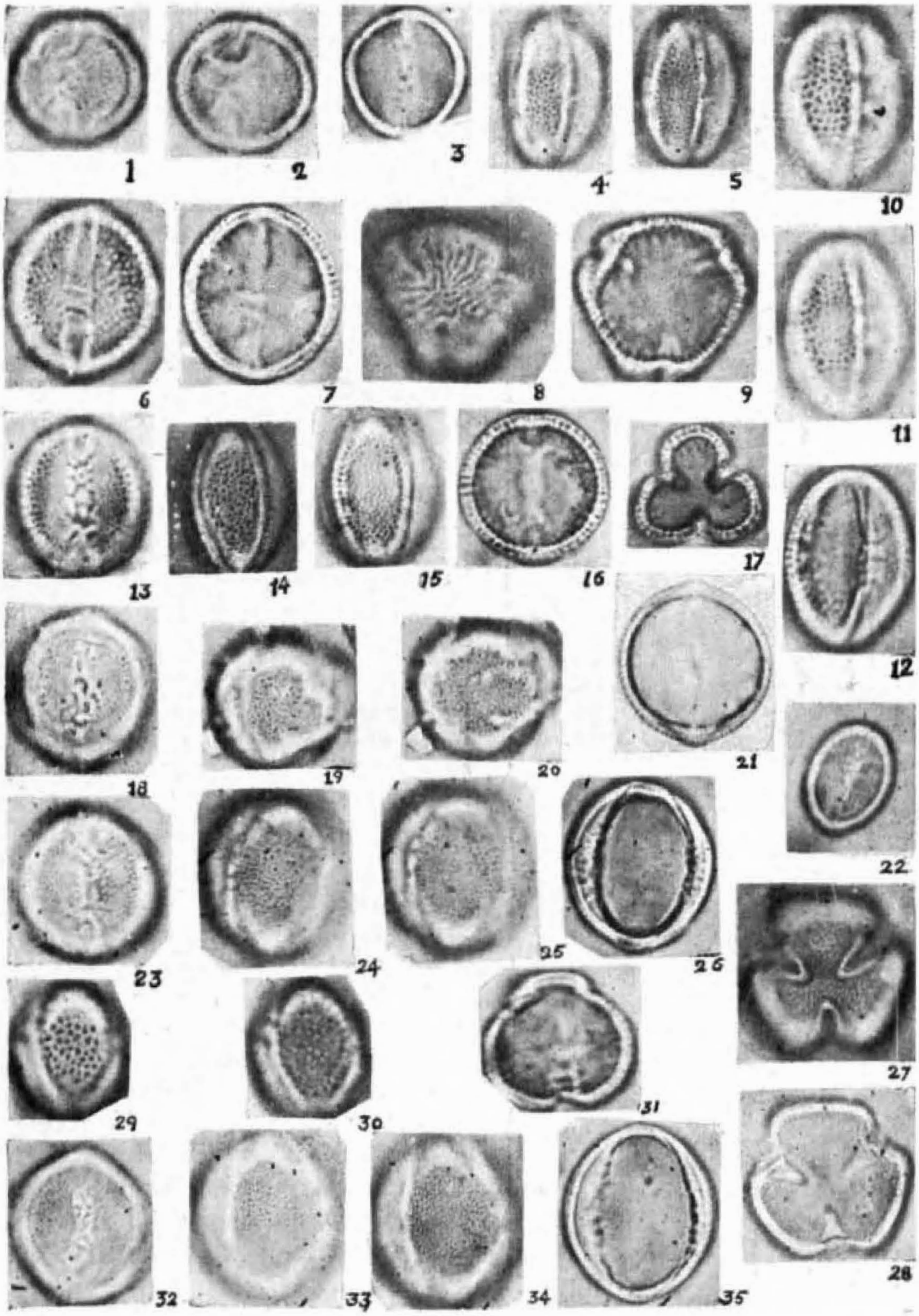

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PLATE I : Figs. 1-35. 1-2. *Oligomeris drageana*. 3-5. *Ol. linifolia*. 6-12. *Ochradenus baccatus*. 13-17. *Reseda alba*. 18-21. *R. alphonsi*. 22. *R. amblyocarpa*. 23-28. *R. crystallina*. 29-31. *R. decursiva*. 32-35. *R. inodora*.

larger at the mesocolpium and smaller at the poles and towards the colpi.

R. alphonsi Muller-Argov. (Tunise/CNH 29915/Pr. no. 6556).

Pollen grains 3-colpate. Prolate (27 × 18.3 μ). P/E ratio 8/5. Ectoaperture 23.5 × 2 μ Endoaperture 14 × 2 μ, granulate. Ectoaperture appears to be granular, smooth only at the two extremities. Exine 1.5 μ reticulate, lumina 0.5 μ to 1 μ

R. amblyocarpa Fresen. (Aden/CNH 29882/Pr. no. 6566).

Pollen grains 3-colporoidate. Subprolate (19 × 14.5 μ). P/E ratio 8/6. Ectoaperture 19 × 3 μ Colpi membrane smooth at the two extremities. Endoaperture 8 × 2 μ, granulate. Exine 1 μ, reticulate, lumina 0.5 μ to 1 μ

R. arabica Boiss (Africa/CNH 29917/Pr. no. 6560).

Pollen grains 3-colpate. Prolate (30 × 21.6 μ). P/E ratio 8/5. Ectoaperture 27 × 2 μ Colpi membrane smooth at the ends. Endoaperture 14 × 2 μ granulate. Exine 1.5 μ reticulate, lumina 0.5 μ

R. aucheri Boiss (India/CNH 29858/Pr. no. 6568).

Pollen grains 3-colporoidate. Prolate spheroidal (20 × 18.7 μ), P/E ratio 8/7. Ectoaperture 18 × 3 μ. Colpi membrane smooth at the ends. Endoaperture 10 × 3 μ granulate. Exine 1.5 μ, reticulate, lumina 0.5 μ to 1.5 μ linear.

R. bracteata Boiss (India/CNH 29849/Pr. no. 6558).

Pollen grains 3-colporate. Subprolate (20.8 × 15.3 μ). P/E ratio 8/6. Ectoaperture 19 × 1.5 μ Colpi membrane smooth. Endoaperture 5 × 2 μ, not clear. Exine 1 μ, reticulate, lumina 0.5 μ

R. crystallina Webb. (Africa/CNH 29924/Pr. no. 6593).

Pollen grains 3-colporoidate. Prolate spheroidal (25.16 × 23.2 μ). P/E ratio 8/7. Ectoaperture 21.5 × 2 μ Colpi membrane smooth at the ends. Endoaperture 10 × 2 μ. Exine 1.5 μ, reticulate, lumina 0.5 μ to 1 μ.

R. decursiva Forsk. (syn. *R. eremophila* Boiss.) (Arab/CNH 29886/Pr. no. 6573).

Pollen grains 3-colporate. Spheroidal (20 × 20.6 μ). P/E ratio 8/8. Ectoaperture 18 × 2 μ. Colpi membrane smooth. Endoaperture 4 × 2 μ, granulate. Exine 1.25 μ

R. inodora Reichenb. (Hungery/CNH 29975/Pr. no. 6619).

Pollen grains 3-colporoidate. Prolate spheroidal (25 × 22.4 μ). P/E ratio 8/7. Ectoaperture 23 × 3 μ Colpi membrane smooth at the ends. Endoaperture 10 × 3 μ, granulate. Exine 1.5 μ, reticulate, lumina 0.5 μ.

R. lutea L. (Asia/CNH 29892/Pr. no. 6575).

Pollen grains 3-colpate. Prolate (27 × 22.8 μ). P/E ratio 8/5. Ectoaperture 21 × 2 μ. Colpi membrane smooth at the ends. Endoaperture 14 × 2 μ, granulate. Exine 1.5 μ, reticulate, lumina 0.5 μ

R. luteola L. (India/CNH 29866/Pr. no. 6620).

Pollen grains 3-colporate. Subprolate (19 × 16 μ). P/E ratio 8/6. Ectoaperture 16 × 1.5 μ Colpi membrane smooth. Endoaperture 5 × 1.5 μ, granulate. Exine 1 μ, reticulate, lumina 0.5 μ or less.

R. odorata L. (India/CNH 29854/Pr. no. 6585).

Pollen grains 3-colpate. Prolate spheroidal (23.4 × 22.3 μ). P/E ratio 8/7. Ectoaperture 20 × 3 μ Colpi membrane smooth at the end. Endoaperture 14 × 3 μ, granulate. Exine 1.5 μ Reticulate, lumina 0.5 μ to 1 μ

R. phyteuma L. sbusp. **collina** Batt. (syn. *R. collina* J. Gray). (Africa/CNH 29923/Pr. no. 6621).

Pollen grains 3-colpate. Prolate (24.5 × 23.5 μ). P/E ratio 8/7. Ectoaperture 21 × 3 μ Colpi membrane smooth at the ends. Endoaperture 12 × 3 μ Exine 1.5 μ, reticulate, lumina 0.5 μ.

R. pruinosa Del. (India/CNH 29857/Pr. no. 6557).

Pollen grains 3-colporoidate. Subprolate (21.2 × 17.6 μ). P/E ratio .8/6. Ectoaperture 18 × 2 μ. Colpi membrane smooth at the ends. Endoaperture 10 × 2 μ, granulate. Exine 1.5 μ, reticulate, lumina 0.5 μ.

R. scoparia Brouss. (Africa/CNH 29953/Pr. no. 6542).

Pollen grains 3-colpate. Prolate spheroidal (21.6 × 19.3 μ). P/E ratio 8/7. Ectoaperture 11 × 2 μ, granulate. Exine 1.5 μ, reticulate, lumina 0.5 μ or less.

R. suffruticosa Loelf. (Syria/CNH 29904/Pr. no. 8020).

Pollen grains 3-colpate. Oblate spheroidal (19.8 × 20.8 μ). P/E ratio 7/8. Ectoaperture 17 × 2 μ. Colpi membrane smooth at the ends. Endoaperture 11 × 2 μ., granulate. Exine 1.5 μ, reticulate, lumina 0.5 μ to 2 μ, rhomboidal.

TRIBE II: CAYLUSEEAE (Plate II; Figs. 60-67).

Caylusea abyssinica Fisch. et May. (Abyssinia/CNH 29842/Pr. no. 6595).

Pollen grains 3-colpate. Prolate (32.9 × 21.6 μ). P/E ratio 8/5. Ectoaperture 31 × 3 μ. Endoaperture same as the ectoaperture as apparent from the distribution of granules throughout the colpal length. Exine 1.5 μ, reticulate, lumina 0.5 μ at the mesocolpium and appearing striate towards colpi.

C. hexagyna (Forsk.) M. L. Green (syn. *C. canescens* A. St. Hill.) (Arabia/CNH 29841/Pr. no. 6604).

Pollen grains 3-colpate. Prolate (31.2 × 25.4 μ). P/E ratio 8/6. Ectoaperture 26 × 4 μ. Endoaperture as in *C. abyssinica*. Reticulate 0.5 μ or less. Very fine reticulation at the mesocolpium and striate towards colpi. Exine 1 μ

TRIBE III. ASTROCARPEAE (Plate II; Figs. 68-71).

Astrocarpus sesamoides (L.) Duby (Europe/CNH 29885/Pr. no. 6559).

Pollen grains 3-colpate. Subprolate (21 × 18 μ). P/E ratio 8/6. Ectoaperture 19 × 1.5 μ Endoaperture extends almost to the entire of the ectoaperture length. Exine 1.5 μ, reticulate, lumina 0.5 μ or less.

Ol. = Oligomeris ; O. = Ochradenus

DISCUSSION

Pollen morphological findings:

Resedaceae is, pollen morphologically, a stenopalynous family. The pollen size ranges from 19 × 14.5 μ in *Reseda amblyocarpa* to 32.9 × 21.6 μ in *Caylusea abyssinica*. In most of the species the range of polar axis is between 19 μ to 25 μ with a few exceptions e.g. *C. abyssinica* 32.9 μ *C. hexagyna* 31.2 μ, *R. arabica* 30 μ *R. alphonsi* and *R. lutea* 27 μ

The apertures are three in number. The ectoaperture (colpa) is long, tapering with acute ends and granulated. The disposition of granules varies in different species, sometimes confined to the middle of the ectoaperture region (colporate) e.g. *Oligomeris drageana, Ol. linifolia, Ochradenus baccatus, Reseda inodora, R. luteola* and sometimes it covers the entire ectoaperture length (colpate) as in *Astrocarpus sessamoides, C. abyssinica, C. hexagyna, R. arabica, R. alphonsi, R. lutea* and *R. odorata*. There exists an intermediate type (colporoidate) between the above types e.g. *R. amblyocarpa, R. aucheri, R. crystallina, R. inodora* and others.

These apertural granules are partly ektexinous and partly endexinous in origin and are constituent of the endoaperture. Same type of granules is also met in the family Capparaceae (Guinet & Mitra).* The morphological nature of this aperture needs to be ascertained with modern microscopy. Ikuse (l.c.) described *R. lutea* and *R. complicata* as 3-colpate grains. In the present study *R. lutea* is described as a colporoidate type on the disposition of granules.

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*Guinet, P. & Mitra, K. during 1971-72 worked on the pollen morphology of the family Capparaceae at the Laboratoire de Palynologie (CNRS), Faculte des Sciences, 34 Montpellier, France, directed by Mme. M. Vancampo.

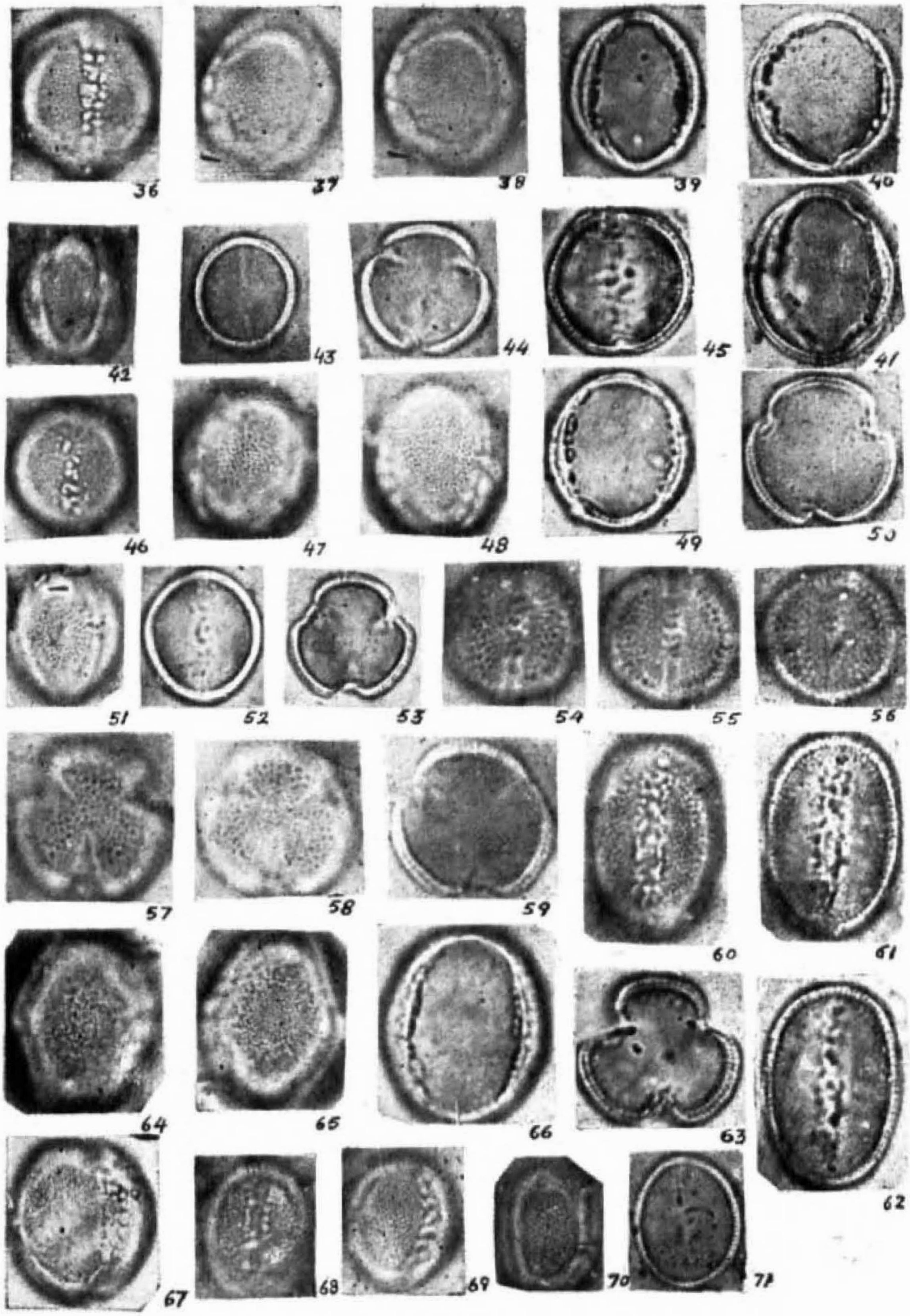

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PLATE II : Figs. 36-71. 36-41. *Reseda lutea*. 42-44. *R. luteola*. 45. *R. odorata*. 46-50. *R. phyteuma*. 51-53. *R. pruinosa*. 54-59. *R. suffruticosa*. 60-63. *Caylusea abyssinica*. 64-67. *C. hexagyna*. 68-71. *Astrocarpus sesamoides*.

The exine is semi-tectate with finely reticulate ornamentation from 0.5 μ to 2 μ. Homobrochate in most species with few exceptions e.g. in *R. alba,* reticulation is hetrobrochate. Here luminii are larger at the mesocolpium and gradually decrease in size towards apocolpal and colpal region. In *Caylusea* species the reticulate ornamentation is striate towards colpal region.

Palynology in relation to taxonomy:

Bolle (l.c.) treated the family under three tribes. Out of the six genera the tribe Resedeae includes four and the other two tribes *viz.* Cayluseeae and Astrocarpae are monogeneric.

In the tribe Resedeae two distinct pollen types have been noted on the pattern of the granules distribution—(1) where the granules are restricted to the middle region (3 μ to 6 μ) and (2) the others where the granules are distributed from 7 μ to 14 μ except the two extremities of the colpi. Any correlation between the size of the pollen grains and the distribution of granules does not exist.

Pollen morphologically the species—*Oligomeris drageana, Ol. linifolia* and *Ochradenus baccatus*—are closely related. The pollen grain size ranges from 21.6 μ to 25.8 μ. The apertural granules are confined to from 3 μ to 6 μ. The pollen grains of *O. baccatus* is slightly bigger than the *Oligomeris* species. Morphologically they are distinct genera. *Oligomeris* is with two undivided petals and four teeth capsules, whereas in *Ochradenus,* the petals are absent and the fruit is a berry. *O. baccatus* and *Ol. linifolia* are extensively distributed geographically and may be regarded as advanced species.

The size of the pollen grains of the *Reseda* species ranges from 19 × 14.5 μ in *R. amblyocarpa* to 30 × 21.6 μ in *R. arabica.* Taxonomically many species have been reported as closely related. *R. amblyocarpa, R. aucheri* and *R. pruinosa* are disputable species. Anderson (1860) regarded *R. aucheri* as a form of *R. pruinosa* from which he distinguished the species *R. amblyocarpa* from Aden, on the structure of seeds. The seeds are rough with minute points in *R. amblyocarpa.* According to Oliver (l.c.) punctate seeds upon which Anderson based his diagnosis are not sufficient to warrant its (*R. amblyocarpa*) separation from *R. pruinosa* in which the seeds are smooth (Balfour, 1887).

In the present pollen morphological investigation and also on the basis of many other morphological characters *R. aucheri* is more closer to *R. pruinosa* but they have been treated as distinct species in the Hooker's flora. The pollen grain size of these two species are more or less same but the exine ornamentation is distinctly reticulate with linear lumini 1 μ to 1.5 μ in the former species and very fine 0.5 μ in the latter, whereas pollen grain of *R. amblyocarpa* is invariably smaller in size than the other two species, especially the equatorial diameter.

In certain species of *Reseda* e.g. *R. decursiva* and *R. alba* the aperture region shows streaks on the colpal membrane which differ from the granules. If the granulation at the aperture is regarded as an advanced character, then these two species may be treated as representatives of the primitive aperture type from which species with granular aperture types are evolved or vice-versa.

The species *R. arabica* is unlike all other *Reseda* species studied and it stands quite apart within the tribe Resedeae (Fig. 1). The pollen grain size is larger than the other species and thereby approaches more closer to the *Caylusea* species of the tribe Cayluseeae. But it differs from the latter species as (1) its colpal ends are smooth which are granulate in the species of *Caylusea* and (2) the exine ornamentation is reticulate and appears to be striate towards the colpi in *Caylusea* species, whereas in *R. arabica* the exine is simply reticulate.

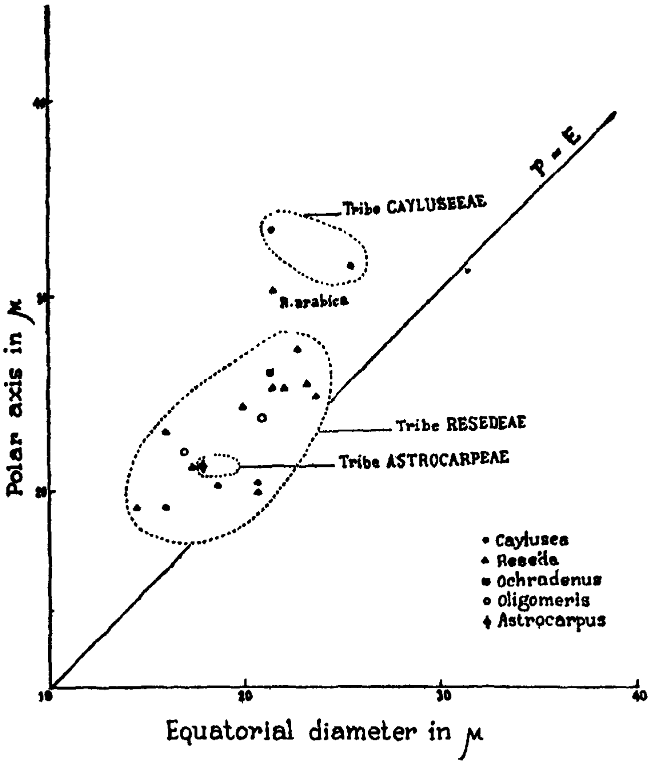

Figure 1: Relationship between different tribes of the Resedaceae on pollen grain character.

The tribe Cayluseeae includes only genus *Caylusea* with two common species *viz. C. abyssinica* and *C. hexagyna.* Taylor (1958) has reported a new species from the tropical Africa *viz. C. latifolia* P. Tayl. on the character of the seeds and the dissected nature of the petals. The seeds of this species resemble those of *C. hexagyna* in structure, and minutely and densely tuberculate surface, but are slightly larger in size, whereas the petal character is quite distinct. As the polliniferous material of *C. latifolia* was not available, its palynological study could not be carried out.

The other two species are distinct palynologically. *C. abyssinica* is slightly larger in size than *C. hexagyna.* The exine ornamentation is reticulate, with striate tendency towards colpal region. The reticulation is very fine (0.5 μ or less) in *C. hexagyna* than in *C. abyssinica* where the lumina is over 0.5 μ

The tribe Cayluseeae stands quite distinct palynologically in the family Resedaceae due to large pollen size, exine ornamentation and the granules at the apertural region. The granules in these two species are distributed from one extremity of the colpi to the other, leaving no surface of the colpal length free, which is apparently very characteristic from all the other species studied.

The tribe Astrocarpae includes monotypic genus *Astrocarpus sesamoides.* This tribe shows close affinity to the tribe Resedeae.

CONCLUSION

Palynologically the family Resedaceae shows close affinities to the tribe Cleomae of the family Capparaceae, on the basis of distribution of granules at the apertural region and sometimes on the character of exine ornamentation, whereas the general structure of the stem as well as the presence of myrosin cells suggest its relationship with the family Brassicaceae (Metcalfe & Chalk, 1950). It is interesting to note that the stomata are not cruciferous in the Resedaceae but are of ranunculaceous type in both the families—Capparaceae and Resedaceae. Moreover, characteristic apertural granules in the pollen grains of these two families are not found in the Brassicaceae. According to Orr (1921) the presence of a third and innermost seed coat in the species of Resedaceae and Capparaceae provides added evidence of the close relationship between the two families. The parietal placentation, the development of a gynophore and an excentric disc leading to medium zygomorphy of the flower and also the dry country habit further support its close relationship with the family Capparaceae. According to Takhtajan (l.c.) the family Resedaceae is probably related to and derived from the Capparaceae.

SUMMARY

Pollen morphological studies on 5 genera and 23 species have been made in the present investigation. Resedaceae is a stenopalynous family. Out of the three tribes, the tribe Cayluseeae is quite distinct pol-

len morphologically due to larger pollen size, apertural granules and exine ornamentation. The tribe Resedae and Astrocarpae show close affinity. *Reseda arabica* Boiss. has larger pollen grains and stands apart in the tribe Resedeae. In this character it approaches the *Caylusea* sp. of the tribe Cayluseeae but in other pollen character they differ.

The apertural granules in this family is interesting. Its nature, origin and significance will be useful. These apertural granules in this family suggest its closer relationship with the tribe Cleomae of the family Capparaceae from the palynological point of view.

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